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RADIOLOGICAL SURVEY

of

HAMPTON ROADS, VIRGINIA

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23

TABLE OF CONTENTS

		Page
I.	Introduction	1
II.	Equipment	1
III.	Procedure	2
IV.	Sample Analyses	3
V.	Description of Area Surveyed	3
VI.	Sample Collection - Gamma Probe Readings	5
VII.	Summary and Conclusions	6
VIII.	References	7
IX.	Tables	15

LIST OF TABLES

Table		Page
I.	Hampton Roads Harbor Sample Gamma Spectral Data	16
II.	Statistical Counting Errors Associated with Specific Nuclides in Selected Silt Samples	19

LIST OF FIGURES

		Page
1.	Hampton Roads Composite Map	8
2.	Norfolk Naval Shipyard - Sampling Locations, Silt Activity	9
3.	Destroyer and Submarine Piers - Naval Operations Base - Sampling Locations, Silt Activity	10
4.	Newport News Shipbuilding and Drydock Company - Sampling Locations, Silt Activity	11
5.	Norfolk Naval Shipyard - Sample Identification No.	12
6.	Destroyer and Submarine Piers at Naval Operations Base - Sample Identification No.	13
7.	Newport News Shipbuilding and Drydock Company - Sample Identification No.	14

I. Introduction

The program of Nuclear Port Surveillance that is conducted by the Southeastern Radiological Health Laboratory in conjunction with the Naval Ship Systems Command, U. S. Navy, was extended in January, 1968, to include the major harbor areas of Hampton Roads, Virginia. Previous surveillance activities have been conducted at Pearl Harbor, Hawaii; Groton, Connecticut; Charleston, South Carolina; San Diego, California; and Mare Island Naval Shipyard near San Francisco, California.

The program objectives at Hampton Roads were to locate, identify and quantitate any radionuclides found in the harbor area resulting from nuclear vessel operations and to assess their public health significance.

II. Equipment

An underwater gamma scintillation detector utilizing a 4 x 4 NaI (Tl) crystal connected to a photomultiplier and pre-amplifier was used to scan the harbor bottom for gamma emitting radionuclides. The crystal, photomultiplier and preamplifier were sealed in a 7"-diameter lucite tube having a wall thickness of ½". A styrofoam jacket protected this assembly from shock and extreme temperatures.

The circuitry used to supply power to the photomultiplier tube on the harbor bottom and transmit pulses to the surface

was developed from RIEL's system[1]. A 400-channel Victoreen PIP pulse height analyzer with associated data printout and punch tape was utilized to identify gamma emitting nuclides on the harbor bottom. The analyzer was connected to the photomultiplier, crystal assembly by means of a waterproof cable. Power was supplied to the system by a 115-V, 60 cycle, portable generator.

Sediment samples were collected from the harbor bottom utilizing a standard Birge-Ekman dredge. Water samples were collected with a bottom weighted metal bottle.

III. Procedure

The gamma scintillation detector was lowered to the bottom and a ten minute *in situ* count was made. Once the count was made, the resulting spectrum was inspected and the data printed out while simultaneously being stored on a punch tape. The counts due to background were automatically subtracted out. The background information was obtained by taking a ten-minute count in an area of the harbor that was determined to be relatively free of activity. The gamma results were used to determine the areas of the harbor that should be sampled.

Samples of bottom silt (three-four liters), harbor water (one gallon) and marine life (clams, oysters and crabs) were collected. The samples were collected from areas delineated by the *in situ* probe readings.

IV. Sample Analyses

The bottom sediment samples were dried at 105°C and ground to a fine powder before being analyzed for gamma activity*. Samples of marine life were dried at 105°C and counted in a 4 x 5 NaI(Tl) well crystal for 50 minutes. Water samples of 3.5 liters were gamma scanned for 50 minutes.

V. Description of Area Surveyed

Hampton Roads, at the southwest corner of Chesapeake Bay, is entered 16 miles westward of the Virginia Capes. It includes the Port of Norfolk, encompassing the cities of Norfolk, Portsmouth, and Chesapeake, and the Port of Newport News, which takes in the cities of Newport News and Hampton. The combined population of these areas is approximately 750,000[2].

Hampton Roads is the world's foremost bulk cargo harbor. Coal, petroleum products, grain, sand and gravel, and fertilizer constitute more than 90 percent of the heavy traffic movement by water, although an increasing amount of general cargo is handled by the Hampton Roads ports.

There are natural depths of 80 to 20 feet in the main part of Hampton Roads, but the harbor shoals to less than 10 feet toward

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*Unless otherwise specified, laboratory gamma analyses consisted of counting samples in a 1-liter Marinelli beaker for 50 minutes over an energy range of 0-3 MeV with a 4 x 4 NaI (Tl) crystal and a 400-channel analyzer.

the shores. Dredged channels lead to the principal ports. Federal project depth is 40 feet in the two main channels in Hampton Roads. One leads southward along the waterfronts of Norfolk, Portsmouth, and Chesapeake following the Elizabeth River, and the other leads westward to the waterfront at Newport News at the entrance to the James River.

The currents are influenced considerably by the winds. The current velocity is 1.1 knots in Hampton Roads and 0.6 knot in the Elizabeth River.

The Hampton Roads area has more than 200 piers and wharves along more than 30 miles of improved waterfront. Some of these facilities are frequently visited by nuclear powered vessels. The composited map shown in Figure 1 approximately outlines the Hampton Roads area. The survey was concentrated in three major areas which are outlined thereon. Two of the areas were in Norfolk harbors, i.e., the Norfolk Naval Shipyard at Portsmouth and an area referred to as the Destroyer and Submarine Piers at Naval Operations Base near the confluence of the James and Elizabeth Rivers. The other area was in Newport News. These areas are numbered as 1, 2 and 3, respectively. Their facilities frequently handle nuclear powered vessels in regard to servicing, drydocking and general maintenance.

VI. Sample Collection - Gamma Probe Readings

Figures 2, 3 and 4 outline the areas from which silt samples were collected and where gamma probe readings were made. Activity levels of ^{60}Co (pCi/gm dry weight) are shown for the silt samples. Not shown on the figures are the locations from which samples of oysters, clams, crabs (biota) and water were collected. Representative samples of biota were collected from the James, Elizabeth and Nansemond Rivers that flow into the Hampton Roads area as well as Chesapeake Bay from which Hampton Roads is entered. Water samples were collected from the three major areas.

Table I outlines the results of laboratory analysis of silt samples. As will be noted, each sample is identified by a laboratory number. Figures 5, 6, and 7 located each silt sample in relation to this number. A total of 28 water samples and 5 biota samples were collected. No significant gamma activity was detected in these samples other than ^{40}K.

The gamma spectra of the silt samples were resolved by utilizing a 12 x 12 matrix. The statistical counting errors associated with the results of three selected spectra, representing low, medium and high levels of ^{60}Co are presented in Table II. This table shows the approximate errors associated with each nuclide with the three levels of ^{60}Co present and will make it possible to relate approximate errors to all data submitted in this report. It should be noted that whenever a sample has a relatively high concentration of one or more nuclides, the accuracy of the determination of other nuclides in the matrix is affected and the minimum limits of detectability are effectively raised.

VII. Summary and Conclusions

No radionuclides other than ^{40}K were detected in harbor water and biota samples. Trace amounts of ^{106}Ru and ^{95}Zr-^{95}Nb were detected in biota samples. Thorium-232 and ^{40}K were also detected, ^{40}K being the predominant radionuclide. ^{144}Ce, ^{137}Cs, ^{95}Zr-^{95}Nb, ^{232}Th, ^{60}Co, ^{40}K, and ^{214}Bi were detected in the majority of the silt samples collected. ^{60}Co was the only radionuclide detected that can be attributed to nuclear vessel operation. The highest concentration of any single radionuclide in silt was 105 pCi/gm of ^{60}Co. The next highest concentration of ^{60}Co was 17.7 pCi/gm. Both samples were collected at Norfolk Naval Shipyard near the entrance to Dry Dock No. 2 in the vicinity of a laundry effluent dump. Lower levels of ^{60}Co (<5 pCi/gm) were detected in silt collected near Dry Docks 1 and 3. The maximum activity in those areas was 3.1 pCi/gm. A maximum of 3.6 pCi/gm was detected in silt collected from slip number 3, and 0.9 pCi/gm in slip number 5. Upstream and downstream from the areas mentioned, the silt activity dropped to below 1 pCi/gm (see Fig. 2).

The ^{60}Co activity in silt at Newport News was found to be concentrated in the two slips between piers 8 and 10. The maximum activity concentration was 9.9 pCi/gm (see Fig. 4).

^{60}Co activity in silt in the area of the Destroyer and Submarine Piers was found to have a maximum value of 4 pCi/gm (see Fig. 3).

In summary, the ^{60}Co deposition was found to be relatively localized and was not detected in any of the biota or water samples. Therefore, based on the information gathered from this survey, it is concluded that no public health hazard exists in Hampton Roads as of January 1968 as a result of nuclear vessel operation.

VIII. References

(1) Riel, G. K,, New Underwater Gamma Spectrometer, Electronics, March 1963, pp. 56-58.

(2) Rand McNally & Company, Road Atlas, 43rd Annual Edition, 1967, p. 111.

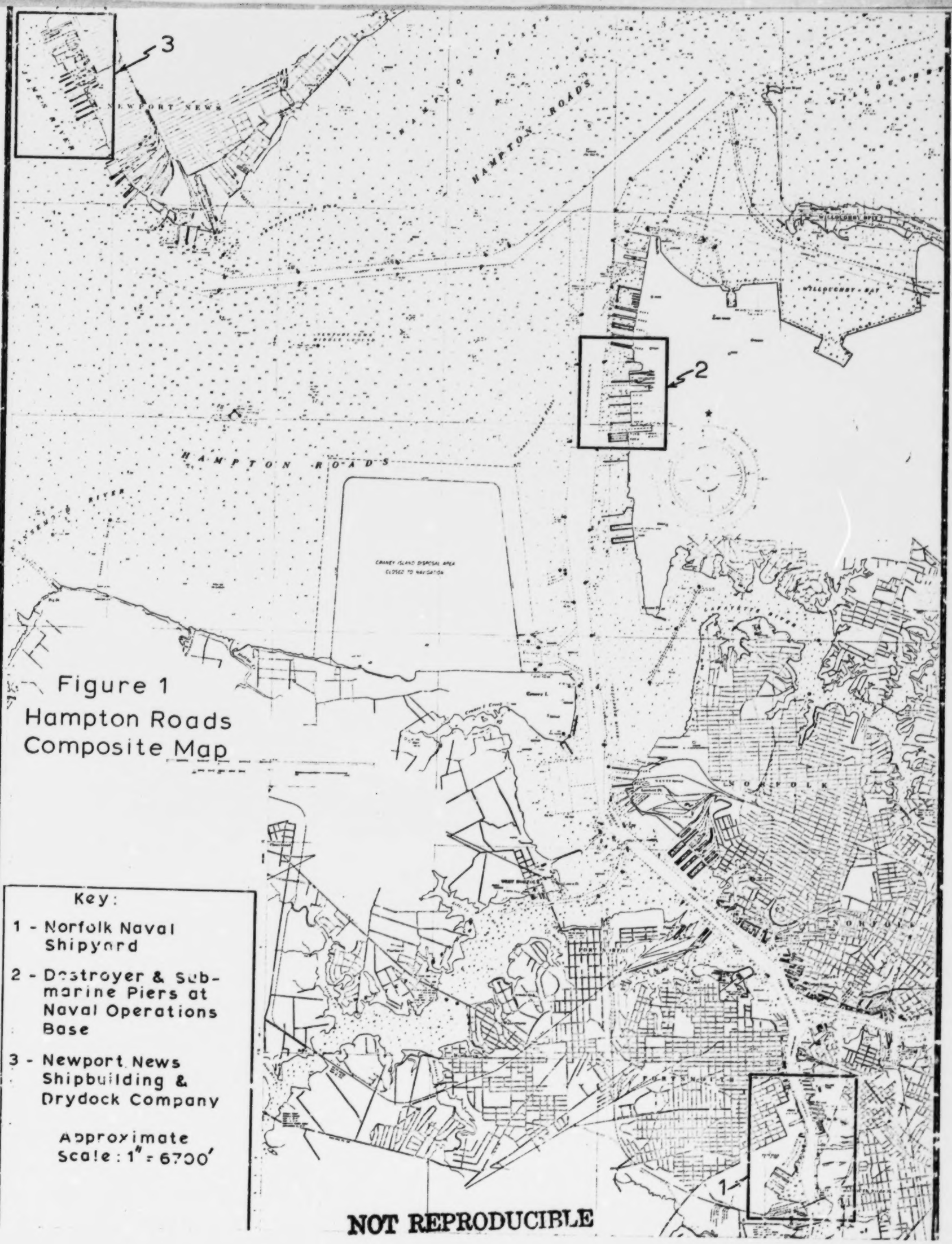


Figure 1
Hampton Roads
Composite Map

NOT REPRODUCIBLE

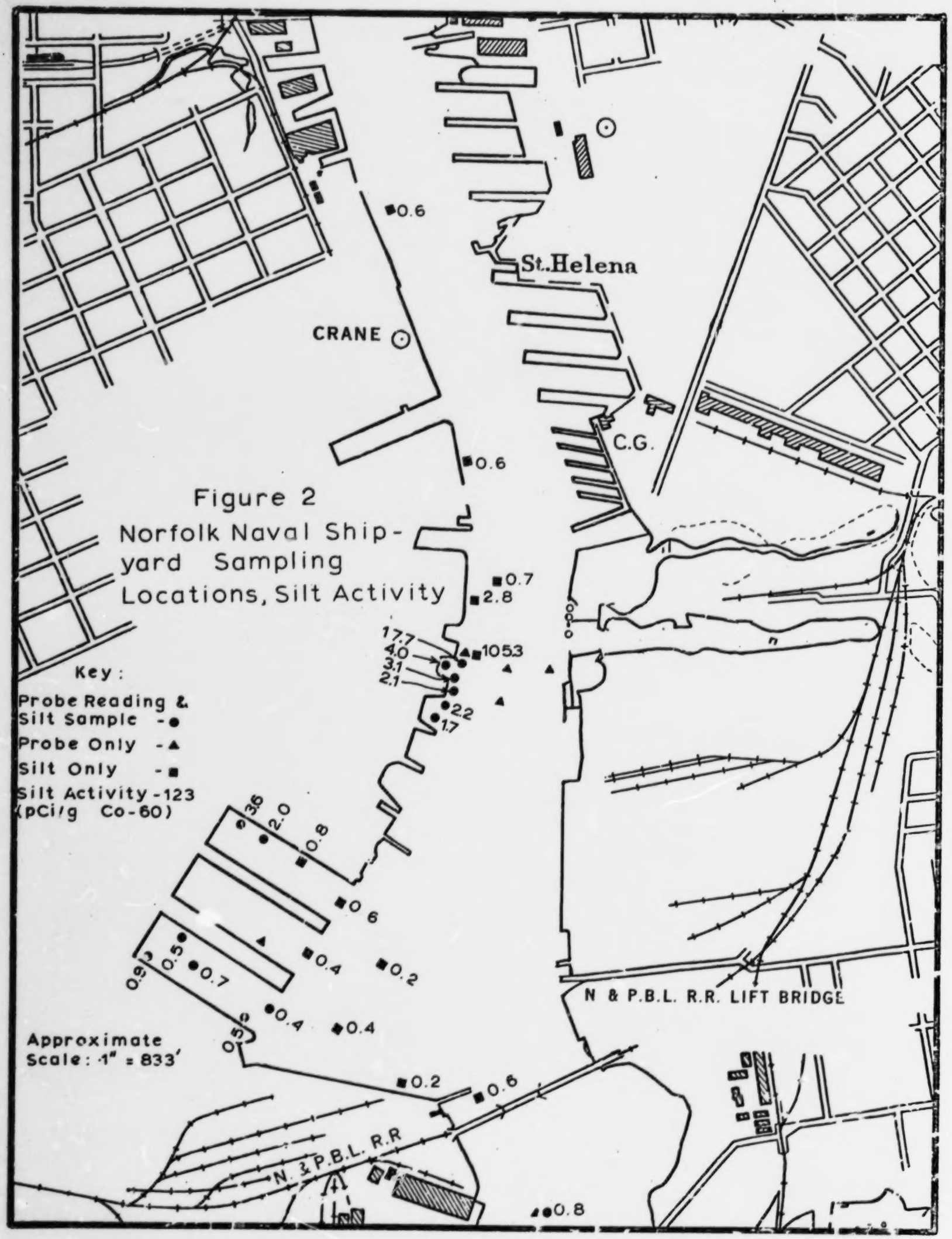
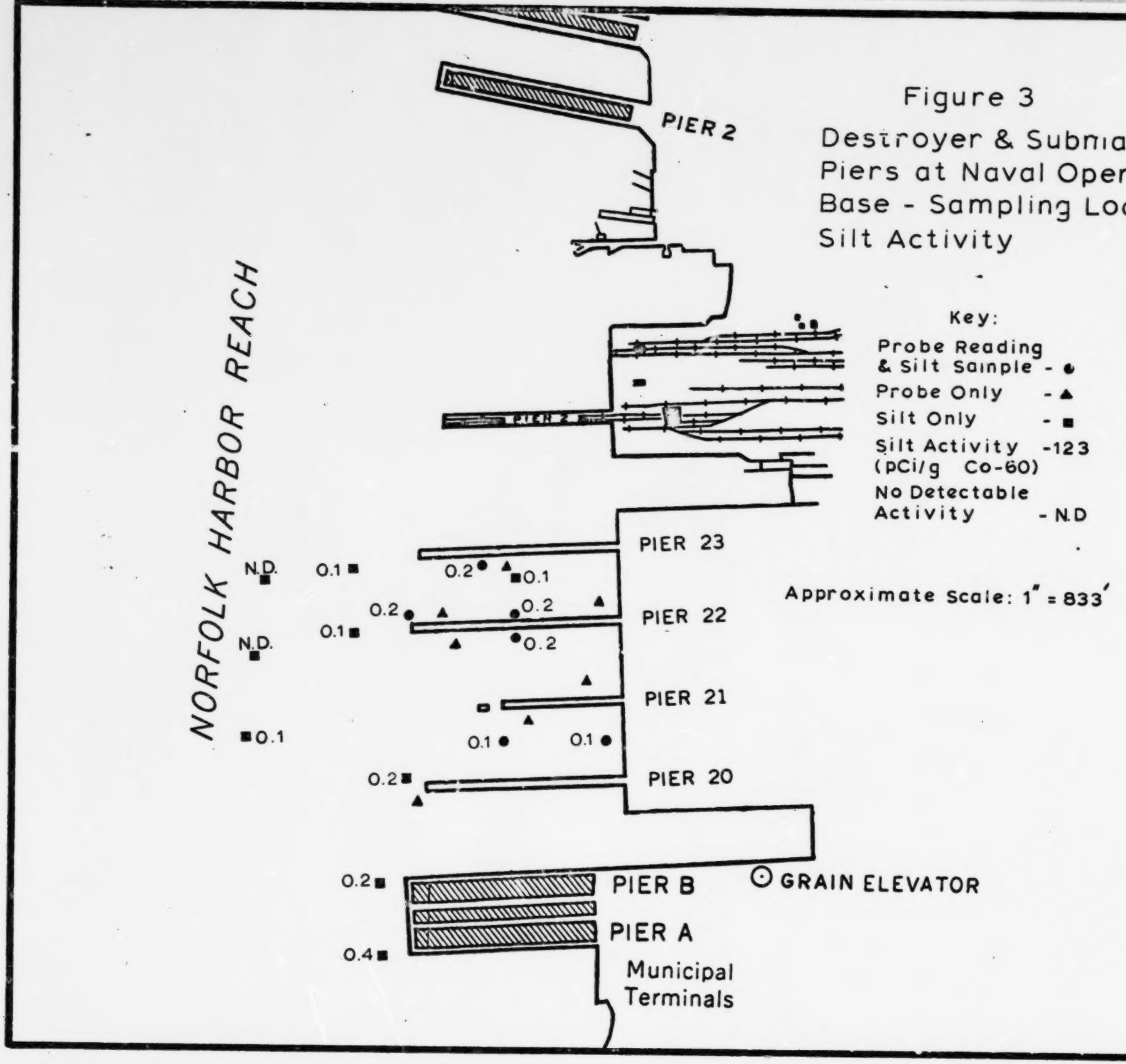


Figure 2
Norfolk Naval Shipyard Sampling Locations, Silt Activity

Figure 3

Destroyer & Submarine Piers at Naval Operations Base - Sampling Locations, Silt Activity



Key:

Probe Reading & Silt Sample - ●

Probe Only - ▲

Silt Only - ■

Silt Activity (pCi/g Co-60) -123

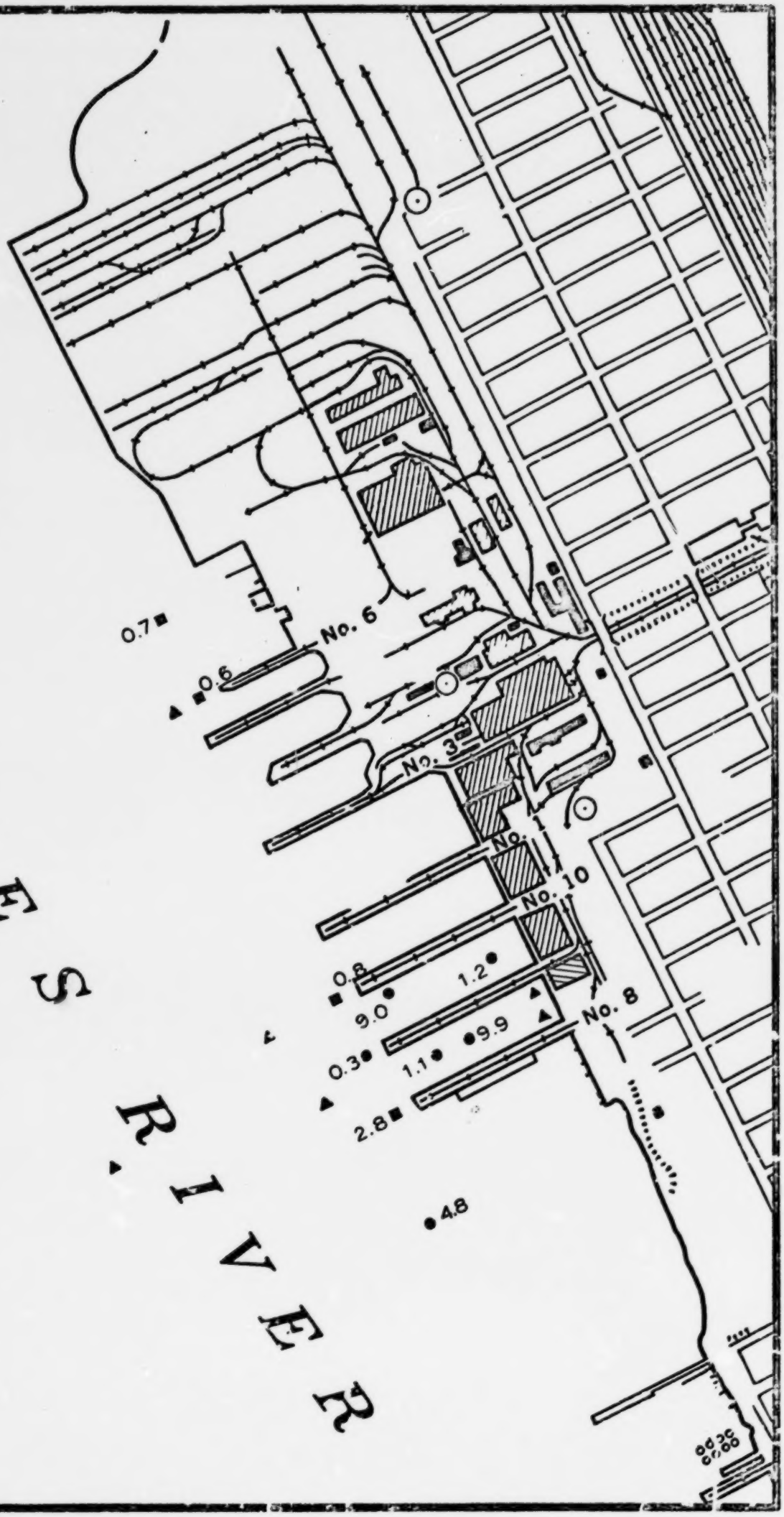
No Detectable Activity - N.D

Approximate Scale: 1" = 833'

Figure 4

Newport News Shipbuilding & Drydock Company Sampling Locations, Silt Activity

Approximate Scale: 1" = 833'



Key:

Probe Reading & Silt Sample - ●
Probe Only - ▲
Silt Only - ■
Silt Activity - 123 (pCi/g Co-60)

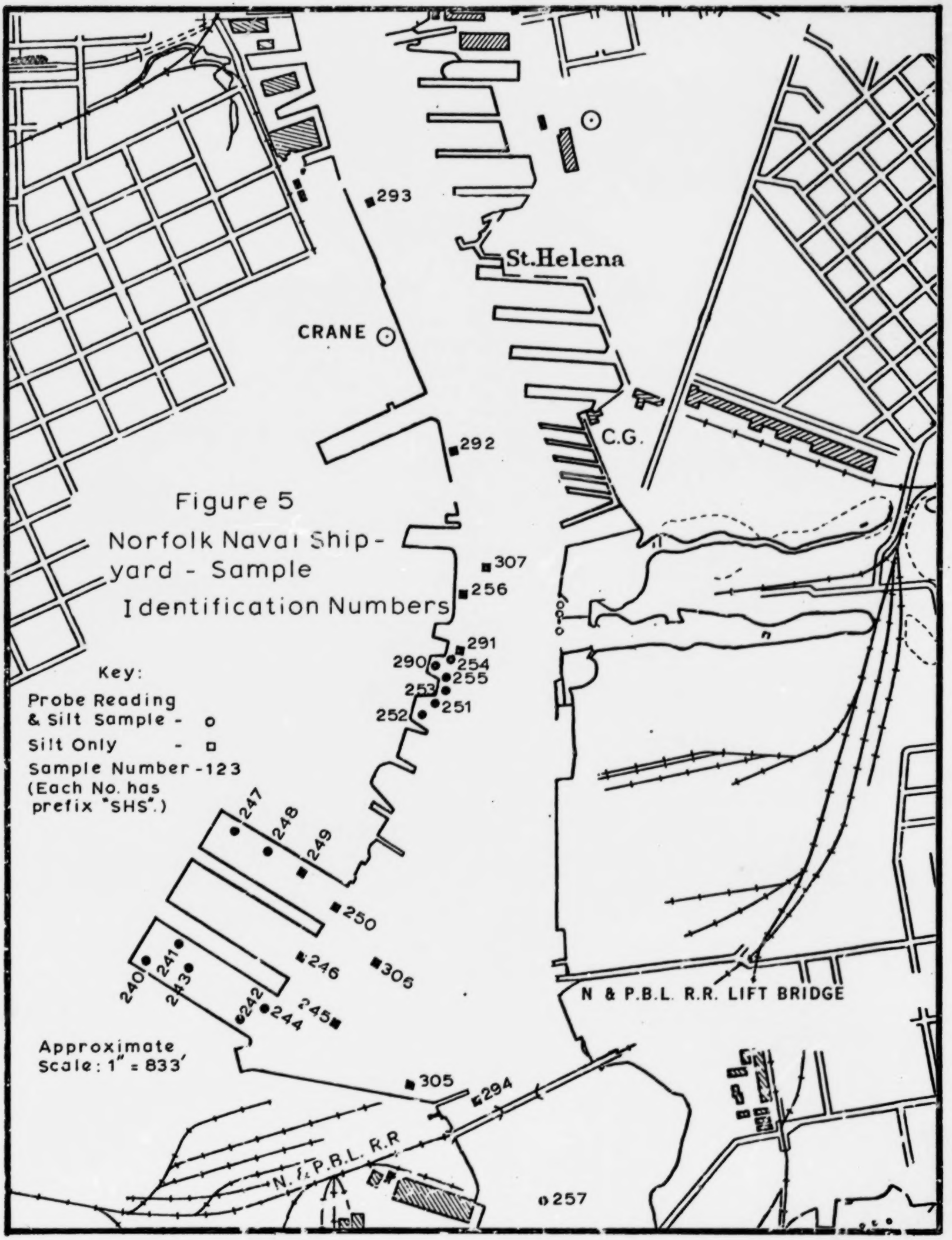


Figure 5

Norfolk Naval Ship-yard - Sample Identification Numbers

Figure 6

Destroyer & Submarine Piers at Naval Operations Base - Sample Identification Numbers

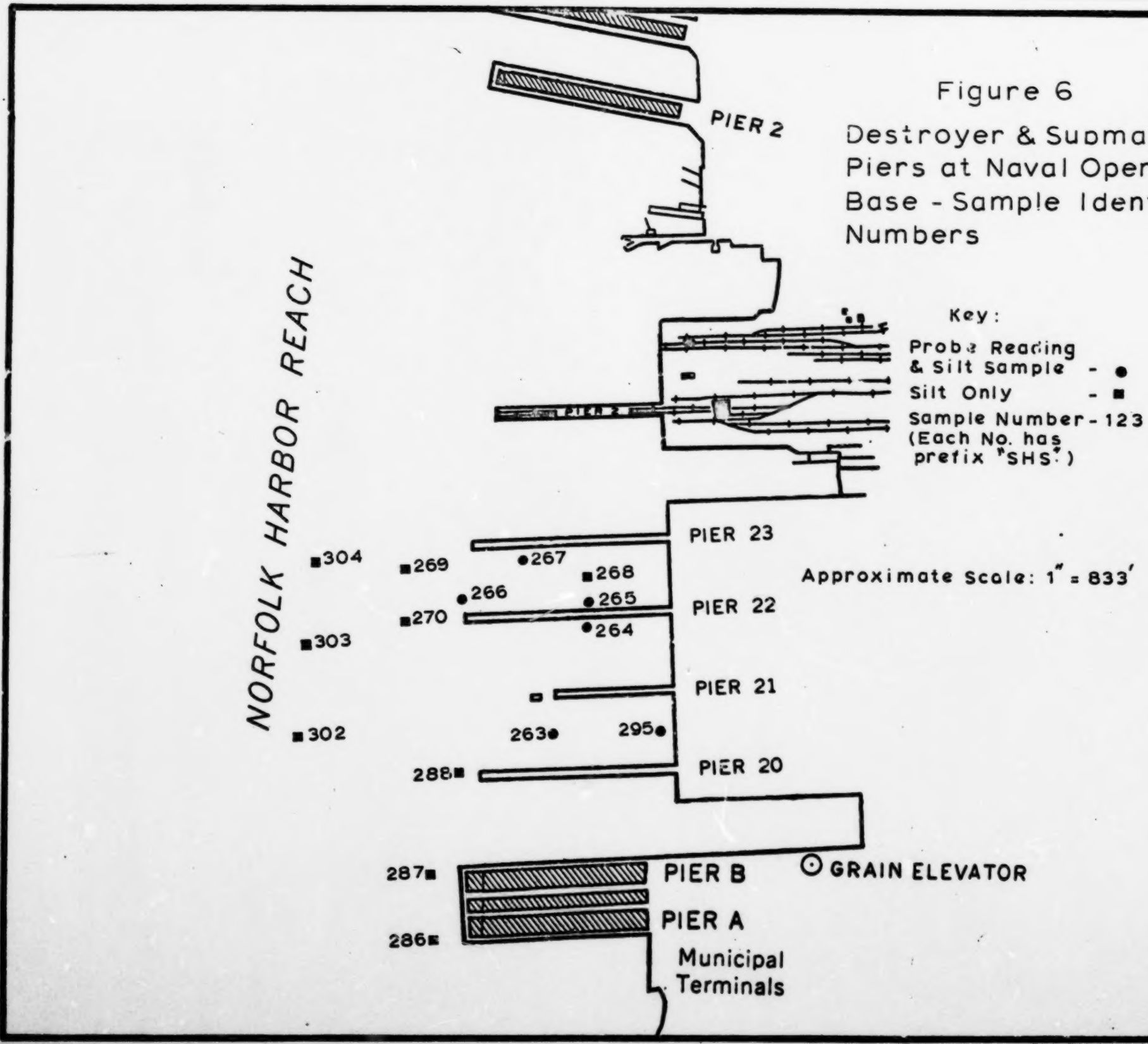
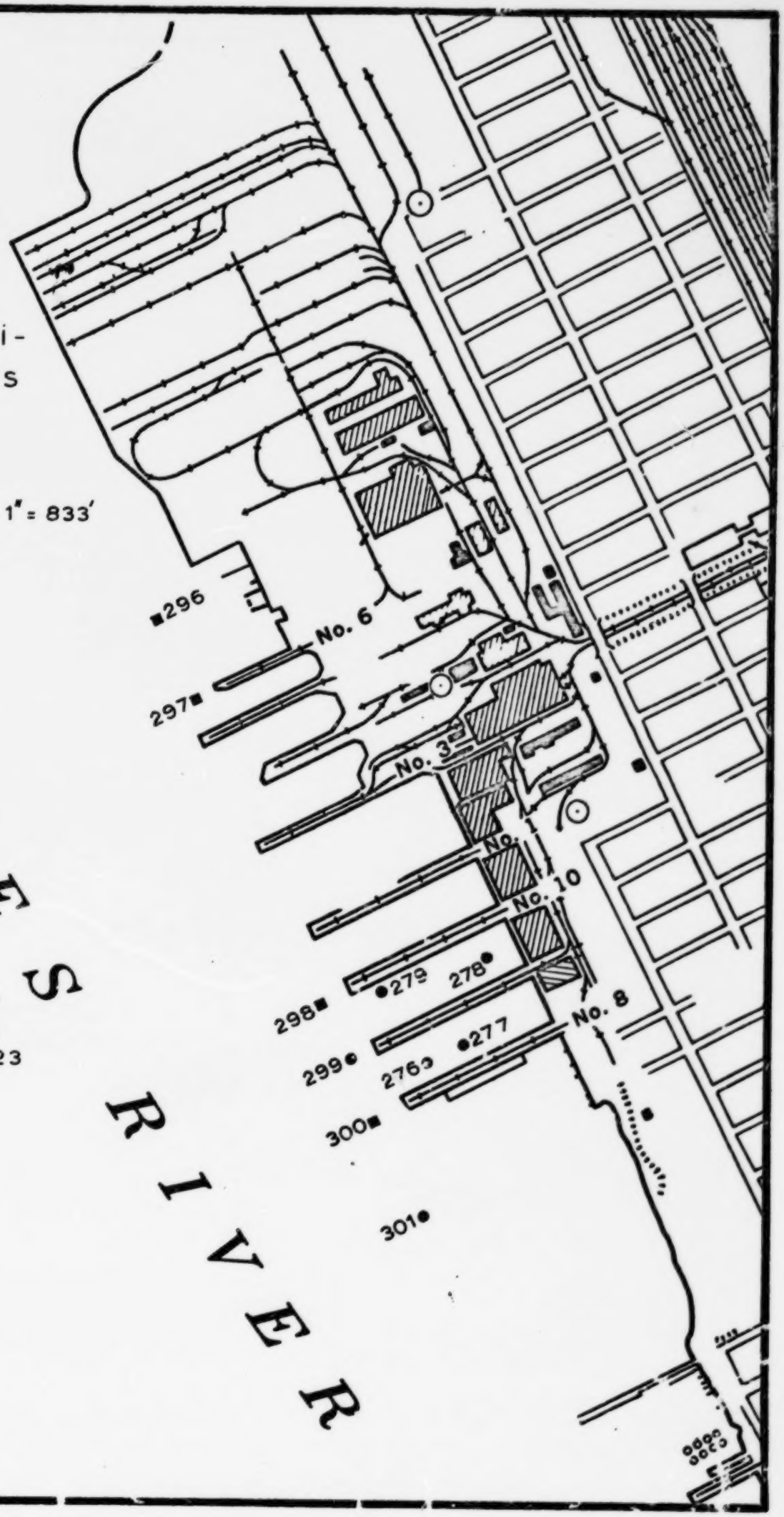


Figure 7

Newport News Shipbuilding & Drydock Co. Sample Identification Numbers

Approximate Scale: 1" = 833'



Key:

Probe Reading & Silt Sample - •

Silt Only - ■

Sample Number - 123 (Each No. has prefix "SHS".)

IX. TABLES

TABLE I
Hampton Roads Harbor Samples
Gamma Spectral Data

SERHL Number	Sample Identification	Type Sample	Gamma Activity - pCi/gm (dry weight)						
			^{144}Ce	^{137}Cs	^{95}Zr-^{95}Nb	^{232}Th	^{60}Co	^{40}K	^{214}Bi
SHS-257	BkG- 1	Silt	1.5	0.9	0.9	0.9	0.8	15.3	0.6
-240	N- 1	"	1.0	1.2	N.D.	0.7	0.9	14.4	0.5
-241	N- 2	"	0.8	0.9	0.2	0.8	0.5	13.6	0.4
-242	N- 3	"	0.8	1.0	0.4	0.8	0.5	15.5	0.5
-243	N- 4	"	0.6	1.0	0.1	0.8	0.7	15.9	0.5
-244	N- 5	"	0.6	0.9	0.3	0.9	0.4	15.9	0.5
-245	N- 6	"	0.6	1.0	N.D.	0.9	0.4	17.2	1.0
-246	N- 8	"	0.8	1.0	N.D.	0.8	0.4	15.0	0.6
-247	N- 9	"	1.0	1.1	0.9	0.7	3.6	15.1	0.5
-248	N-10	"	0.3	0.9	0.4	0.6	2.0	12.7	0.6
-249	N-11	"	1.1	0.7	N.D.	0.8	0.8	12.2	0.8
-250	N-12	"	0.9	0.9	0.3	0.8	0.6	13.7	0.6
-251	N-13	"	1.0	0.9	0.6	0.9	2.2	14.5	0.8
-252	N-14	"	1.0	0.7	0.8	1.0	1.7	13.4	1.0
-253	N-15	"	0.7	0.8	0.2	0.8	2.1	13.6	0.6
-254	N-19	"	1.4	0.7	2.3	0.7	17.7	11.0	1.0
-255	N-21	"	1.0	0.5	1.0	0.9	3.1	11.8	0.8
-256	N-23	"	1.7	0.9	1.4	0.8	2.8	13.6	0.6
-263	N-25	"	2.3	0.7	1.5	0.8	0.2	17.4	0.5
-264	N-29	"	1.8	0.7	1.5	0.8	0.2	18.0	0.5
-265	N-32	"	3.9	0.7	2.5	0.7	0.2	17.1	0.4
-266	N-33	"	1.9	0.7	1.0	0.8	0.2	17.1	0.5

TABLE I (cont'd)
Hampton Roads Harbor Samples
Gamma Spectral Data

SERHL Number	Sample Identification	Type Sample	Gamma Activity - pCi/gm (dry weight)						
			^{144}Ce	^{137}Cs	^{95}Zr-^{95}Nb	^{232}Th	^{60}Co	^{40}K	^{214}Bi
SHS-267	N-36	Silt	1.8	0.7	0.8	0.8	0.2	17.6	0.5
-268	N-37	"	2.1	0.7	1.8	0.7	0.1	16.3	0.5
-269	N-38	"	1.3	0.6	0.8	0.8	0.1	16.9	0.7
-270	N-39	"	1.8	0.5	0.8	0.8	0.1	16.6	0.5
-276	N-41	"	4.1	0.7	2.8	0.7	1.1	15.5	0.4
-277	N-42	"	3.2	0.8	1.7	0.9	9.9	15.7	N.D.
-278	N-49	"	3.5	0.7	2.4	0.8	1.2	16.2	0.6
-279	N-50	"	2.0	0.6	1.1	0.7	9.0	14.9	0.6
-286	NOB- 1	"	1.4	1.0	0.6	1.1	0.4	23.6	0.7
-287	- 2	"	1.1	0.7	0.8	0.9	0.2	17.9	0.6
-288	- 6	"	2.1	0.7	1.7	0.8	0.2	17.3	0.6
-289	NNSY- 1	"	1.2	1.1	0.2	0.9	0.8	14.3	0.6
-290	-28	"	0.5	0.7	N.D.	0.8	4.0	13.5	0.7
-291	-29	"	N.D.	N.D.	N.D.	N.D.	105.3	N.D.	N.D.
-292	-36	"	1.1	1.5	N.D.	0.8	0.6	13.5	0.6
-293	-41	"	0.6	0.7	0.2	0.9	0.6	14.3	0.6
-294	- 2	"	0.5	0.7	N.D.	0.9	0.6	13.3	0.6
-295	NOB-10	"	1.1	0.6	N.D.	0.7	0.1	15.7	0.4
-296	NN- 1	"	1.2	0.8	0.7	0.8	0.7	15.5	0.6
-297	- 2	"	1.1	0.9	0.2	0.7	0.6	16.2	0.6
-298	- 3	"	1.2	0.6	0.7	0.7	0.8	13.9	0.5
-299	- 4	"	1.0	0.3	0.1	0.7	0.3	11.0	0.6
-300	- 5	"	0.7	0.4	0.1	0.8	2.8	14.4	0.5
-301	- 6	"	0.7	0.6	0.3	0.8	4.8	13.9	0.1

TABLE I (cont'd)
Hampton Roads Harbor Samples
Gamma Spectral Data

SERHL Number	Sample Identification	Type Sample	Gamma Activity - pCi/gm (dry weight)						
			^{144}Ce	^{137}Cs	^{95}Zr-^{95}Nb	^{232}Th	^{60}Co	^{40}K	^{214}Bi
SHS-302	NOB- 7	Silt	1.9	0.7	1.3	0.6	0.1	14.2	0.4
-303	-27	"	1.9	0.6	1.2	0.6	N.D.	13.8	0.4
-304	-29	"	1.5	0.6	0.9	0.5	N.D.	14.1	0.4
-305	NNSY- 3	"	0.7	1.0	0.3	0.8	0.2	14.1	0.5
-306	-13	"	0.6	0.9	0.4	0.7	0.2	15.0	0.5
-307	-33	"	0.8	0.9	0.4	1.3	0.7	14.0	0.4

N.D. indicates activity not detectable.

TABLE II

Statistical Counting Errors Associated with Specific Nuclides in Selected Silt Samples - Results in pCi/gm*

Isotope	Sample Identification		
	N-4	N-19	N-21
Cerium-144	0.6 ± 40%	1.4 ± 30%	1.0 ± 25%
Cesium-137	1.0 ± 10%	0.7 ± 15%	0.5 ± 15%
Zirconium - Niobium-95	0.1 ± 50%	2.3 ± 5%	1.0 ± 5%
Thorium-232	0.8 ± 15%	0.7 ± 30%	0.9 ± 15%
Cobalt-60	0.7 ± 10%	17.7 ± 2%	3.1 ± 5%
Potassium-40	15.9 ± 5%	11.0 ± 10%	11.8 ± 5%
Bismuth-214	0.5 ± 25%	1.0 ± 20%	0.8 ± 20%

* Error expressed relative to 2 sigma confidence level.